Geoacoustic Database Development for the ESME Initiative

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LONG-TERM GOALS

Our long-term objective is to establish a database of sediment and bottom properties including sediment compressional wave speed, shear wave speed, attenuation and density. Using this we propose to provide the best sediment model for any region with estimates of model uncertainty. These data would be appropriate for incorporation in state-of-the-art propagation models for acoustic effects prediction on the marine environment.

OBJECTIVES

1.   Develop a surficial sediment model for the world's oceans based on optimal estimation techniques, geological models and data.

2.   Integrate the sediment model into WHOI oceanographic models for input to ray/ normal mode/ PE based sonar effects studies.

3.   Provide estimates for model uncertainty.

4.   Apply this model in selected regions to test its accuracy and effectiveness.

APPROACH

As a first step we plan to collect all the available sediment property data at the region of interest. This includes all the geoacoustic (compressional wave speed, shear wave speed, attenuation etc.) and geotechnical properties (bulk density, permeability, porosity etc.). The geotechnical properties can be used to derive geoacoustic properties using a suitable model. These data can be obtained from literature or from available sediment property databases. In addition to these direct measurements of sediment properties we intend to collect other parameters which influence sediment distribution at any given region. These factors include, water depth at the location, distance to the shore, region, latitude, current speed and proximity to major river discharge

After collecting the data as described above, the next step is to express the non-linear model-data relationship in the form:

d=G (m)

where

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 2002**	2. REPORT TYPE	3. DATES COVERED **00-00-2002 to 00-00-2002**

4. TITLE AND SUBTITLE **Geoacoustic Database Development for the ESME Initiative**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of Rhode Island,Department of Ocean Engineering,,Narragansett,,RI, 02881**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
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15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**6**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

$$
d = \begin{bmatrix} \text{water depth} \\ \text{distance from shore} \\ \text{latitude} \\ \cdots\cdots \\ \cdots\cdots \\ \cdots\cdots \\ \cdots\cdots \\ \cdots\cdots \\ \cdots\cdots \end{bmatrix}
$$

and

$$
\mathbf{m} = \begin{bmatrix} c(r) \\ \rho(r) \\ \alpha(r) \end{bmatrix}
$$

The matrix **G** defines the non-linear relationship between the sediment data (**m**) and the factors which influence them (**d**). The main task then will be to generate the kernel **G** based on the relationship between **d** and **m**. Various sediment geoacoustic models (Hamilton[4], Bowles[5] etc.) sediment transport models and geological information can be used to develop the kernel matrix **G**. We plan to proceed as follows:

1. Collect all the geoacoustic parameters available at various sites in the region of interest.

2. Collect also other parameters of influence like water depth, latitude, distance from shore, etc.

3. Develop a relationship (G) between these parameters using half of the available data.

4. Using G, predict the remaining half of the data and compare with the true data and thereby test the model. Tune the model until there is good agreement.

5. Using G calculate the geoacoustic parameters at any location.

WORK COMPLETED

A sediment model suitable for the Southern California Bight (SOCAL) region was first developed. The second test case corresponds to the Middle Atlantic Bight region. A program was written to generate sediment parameters for the Middle Atlantic Bight region which was chosen as the test site in the last (August 2001) ESME workshop. The location lies between latitudes 37 N and 43 N and 66 W and 74 W. The program is written in such a way that given the location and the frequency of interest, the sediment properties are estimated using all the available data. The sediment information available includes core data, sediment maps, sediment type information etc. For this location we were able to find some historical data which is listed below.

1. Core data:

   ♦ Atlantic Margin Coring Sites 6009 to 6021[1,2]. The sediment type information, sediment properties, layer thickness etc. were obtained from these.

   ♦ Gravity core data[3]. Gravity cores were taken and analyzed from five locations as part of Primer study.

   ♦ Vibrocore data

   ♦ Piston Core data from USGS mapping program[4]

2. Sediment type information: from USGS sediment maps for the area[5].

3. Compressional wave speeds and layer thickness using high resolution seismic studies (Brocher and Ewing)

4. Sediment sound velocity functions for North Atlantic (Houtz)

5. Sediment tomography using Primer data (Potty et.al.)

6. Thickness of surficial sand sheet (Knebel and Spiker)

7. Compressional wave velocities from multichannel refraction arrivals (Mc Ginnis and Otis)

8. Compressional and shear wave speeds using gravity wave inversion technique (Trevorrow and Yamamoto)

9. Sediment and geoacoustic models: Used for predicting the compressional and shear wave speeds as well as attenuation as function of frequency for different sediment types. These include Hamilton model[11], Bowles[12], and Biot- Stoll model[13].

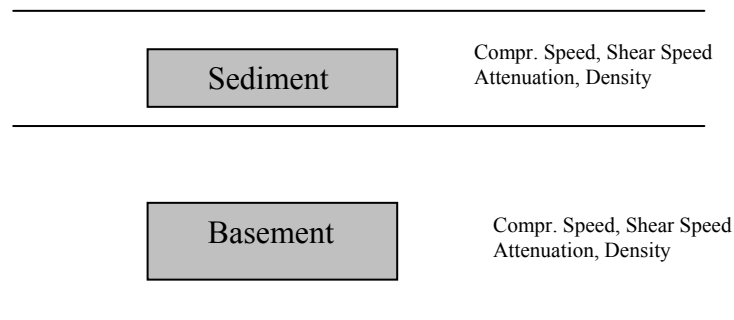10. Sediment layer thickness maps[8]: Used for predicting the sediment thickness.

Figure 1. Two layer model to represent the sediment properties used in this study.

The program uses these data to arrive at the sediment parameters at a given location. The sediment compressional speed is estimated using the core data, sediment type information and the Hamilton's values for these sediment types. Sediment thickness is estimated based on the core data and sediment thickness map. Shear speed, and Compressional and shear attenuation are determined mainly using the sediment type information and predictions by Hamilton and Stoll. The bottom properties are specified for a simple two-layer model. Some of the properties (compressional and shear speeds in the basement) are assumed constant throughout the area. The output parameters are written in a text file.
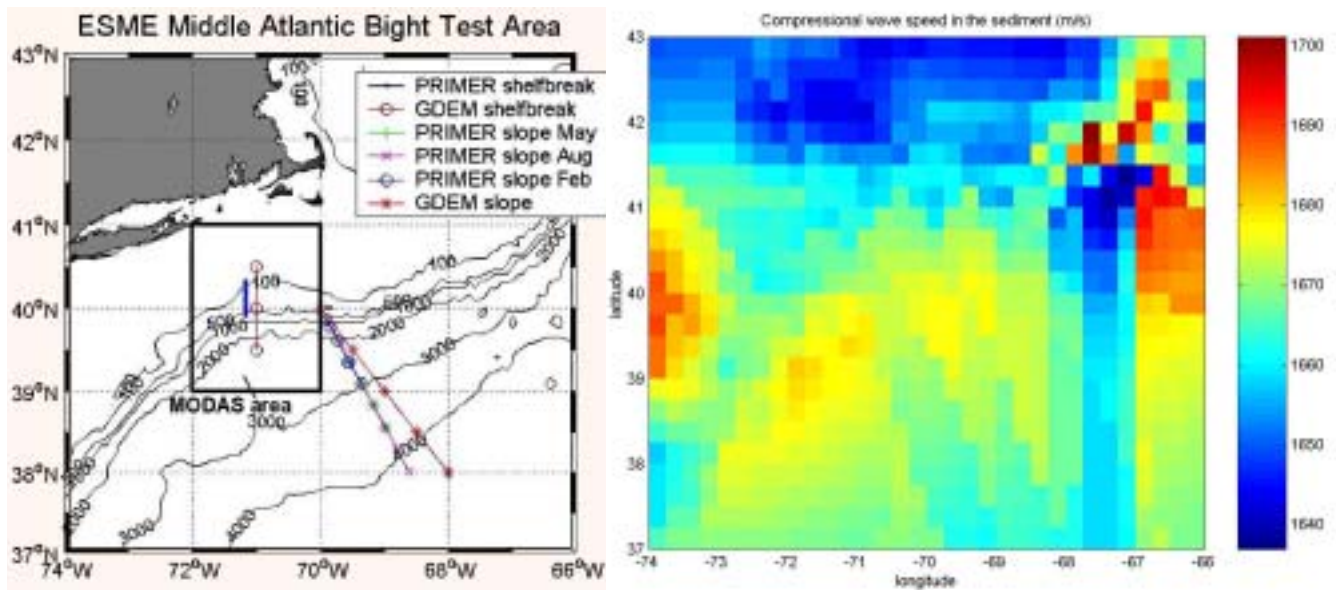
Figure 2. Left panel shows the location of the ESME test case. Right panel shows the sediment sound speed obtained using the sediment model developed.

IMPACT/APPLICATIONS

Our effort is intended to provide the best possible estimates of sediment data needed for the propagation modeling component of the ESME initiative. This will enable the propagation modelers to use 'best guesses' when direct estimates of the sediment data is not readily available.

TRANSITIONS

We expect that this sediment model, when complete, will be useful to the acoustic community as a whole as an important database of sediment property information. This model can be integrated into OAML based on discussions with NAVOCEANO personnel.

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PRESENTATIONS/ CONFERENCE PROCEEDINGS

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